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Edwards et al.

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(54) **COMPONENT CONFIGURATION SYSTEM AND METHODS OF OPERATING SAME**

(75) Inventors: **William Talion Edwards**, Foristell, MO (US); **Timothy Joseph Josten**, St. Peters, MO (US); **Scott Randall Greene**, Defiance, MO (US); **Michael L. Piasse**, St. Charles, MO (US); **Andrew Wall**, O'Fallon, MO (US); **William E. Wojczyk, Jr.**, O'Fallon, MO (US)

(73) Assignee: **The Boeing Company**, Chicago, IL (US)

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G06F 17/50 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 17/50*** (2013.01); *G06F 17/5095* (2013.01); *G06F 2217/02* (2013.01); *Y02T 10/82* (2013.01)

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USPC 707/758
See application file for complete search history.

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Primary Examiner — Jensen Hu
(74) *Attorney, Agent, or Firm* — Armstrong Teasdale LLP

(57) **ABSTRACT**

A system and methods to record a configuration record for components of an asset is provided. The system includes a user interface device comprising a screen having a plurality of attributes and a plurality of link hotspots coupled to the plurality of attributes. A database is coupled to the user interface device, wherein the database includes an aspect associated with each of the plurality of attributes. The system includes a processor coupled to the user interface device and the database, wherein the processor configured to couple the aspect to the plurality of link hotspots.

20 Claims, 11 Drawing Sheets

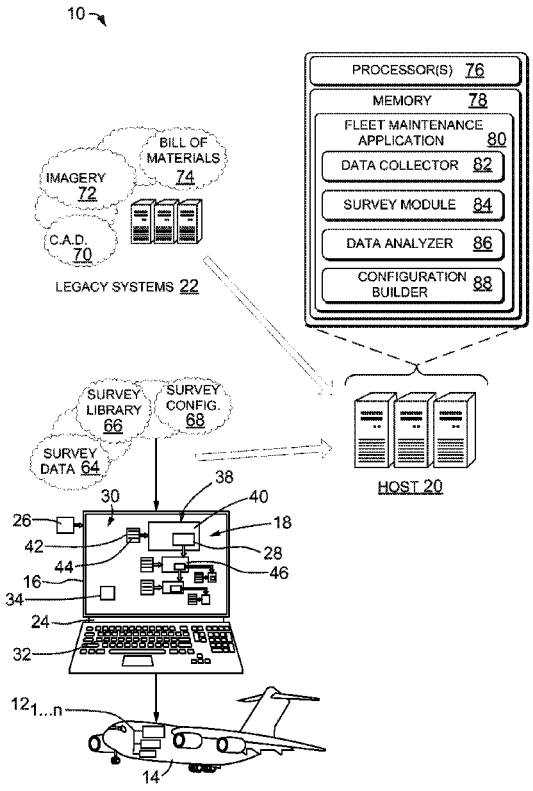


FIG. 1

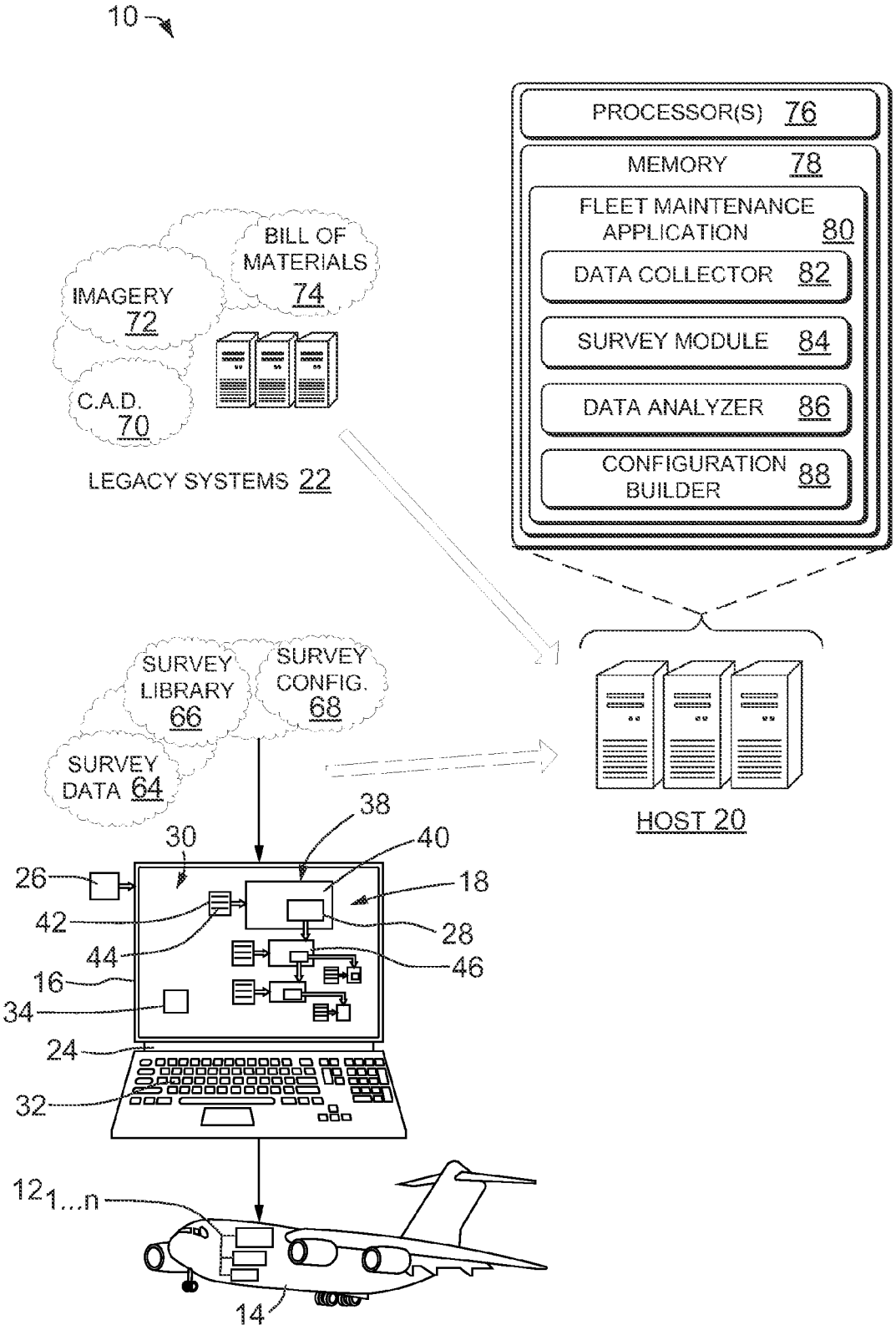

10
PROCESSOR(S) 76
MEMORY 78
FLEET MAINTENANCE APPLICATION 80
DATA COLLECTOR 82
SURVEY MODULE 84
DATA ANALYZER 86
CONFIGURATION BUILDER 88
BILL OF MATERIALS 74
IMAGERY 72
C.A.D. 70
LEGACY SYSTEMS 22
SURVEY LIBRARY 66
SURVEY CONFIG. 68
SURVEY DATA 64
HOST 20
38
40
30
26
18
42
28
44
46
16
34
24
32
12 1...n
14

FIG. 2

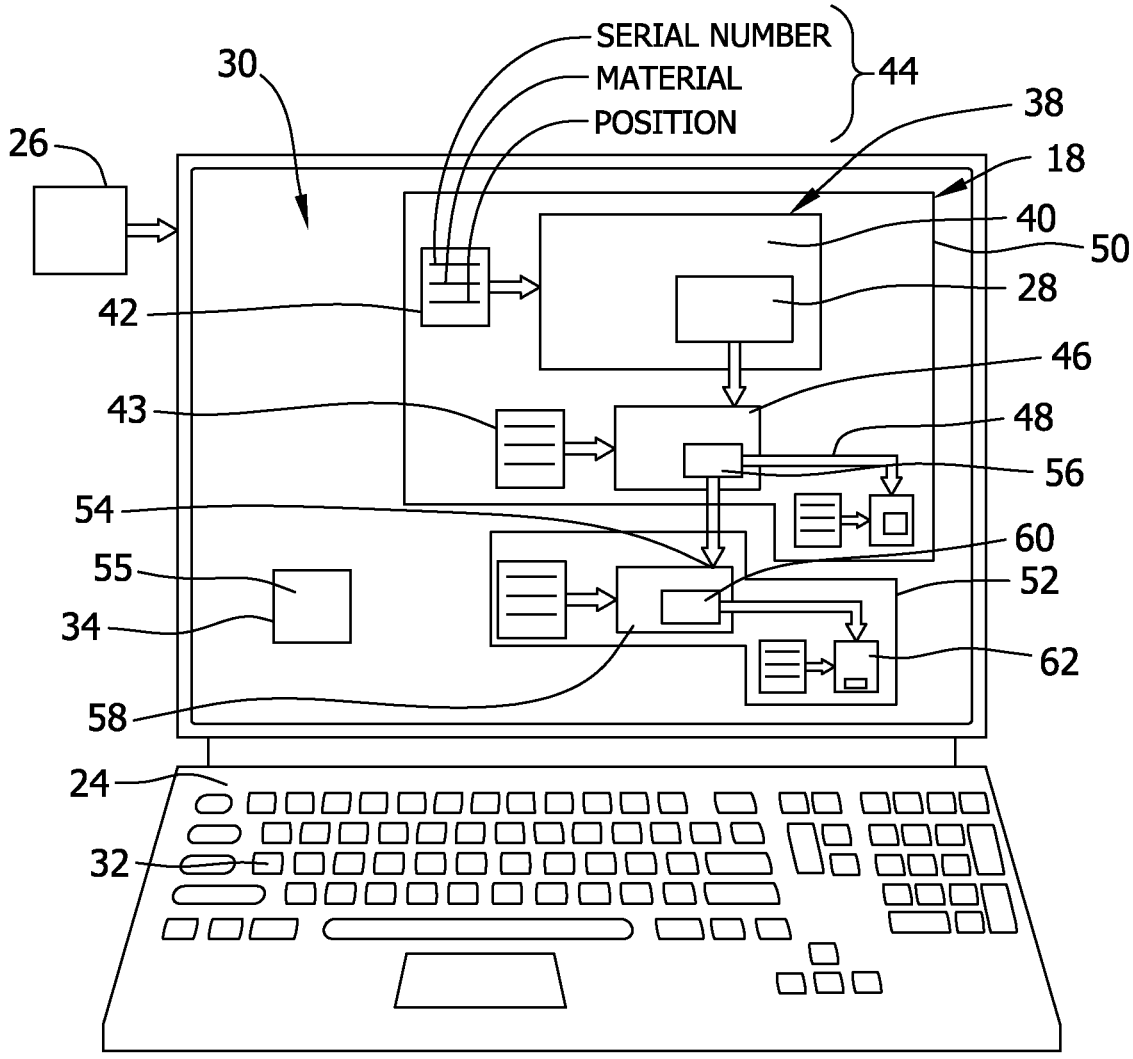
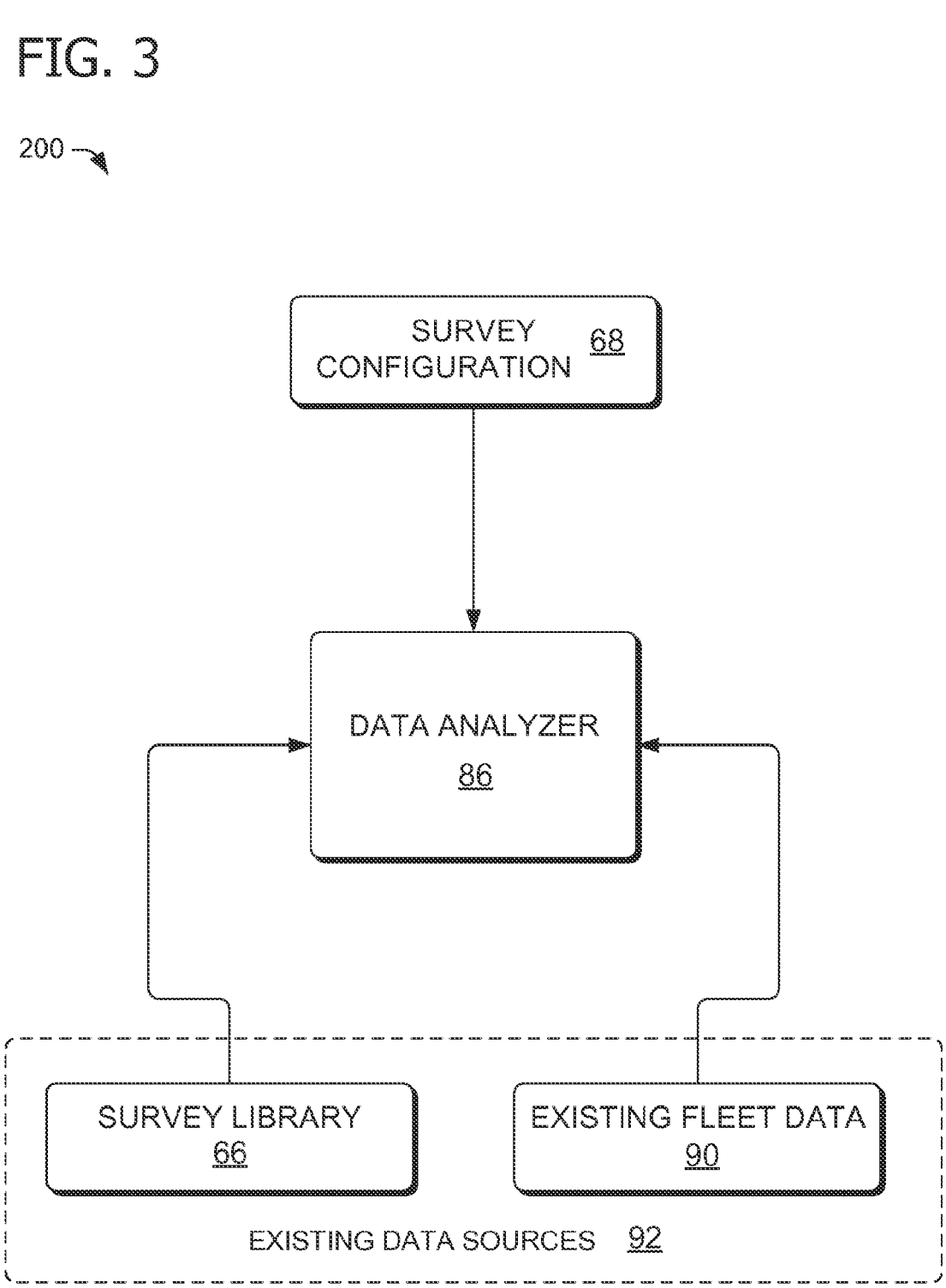

SERIAL NUMBER
MATERIAL
POSITION
44
30
38
26
18
40
50
42
28
46
43
48
56
54
60
55
52
34
62
58
24
32

FIG. 3


200
SURVEY CONFIGURATION 68
DATA ANALYZER 86
SURVEY LIBRARY 66
EXISTING FLEET DATA 90
EXISTING DATA SOURCES 92

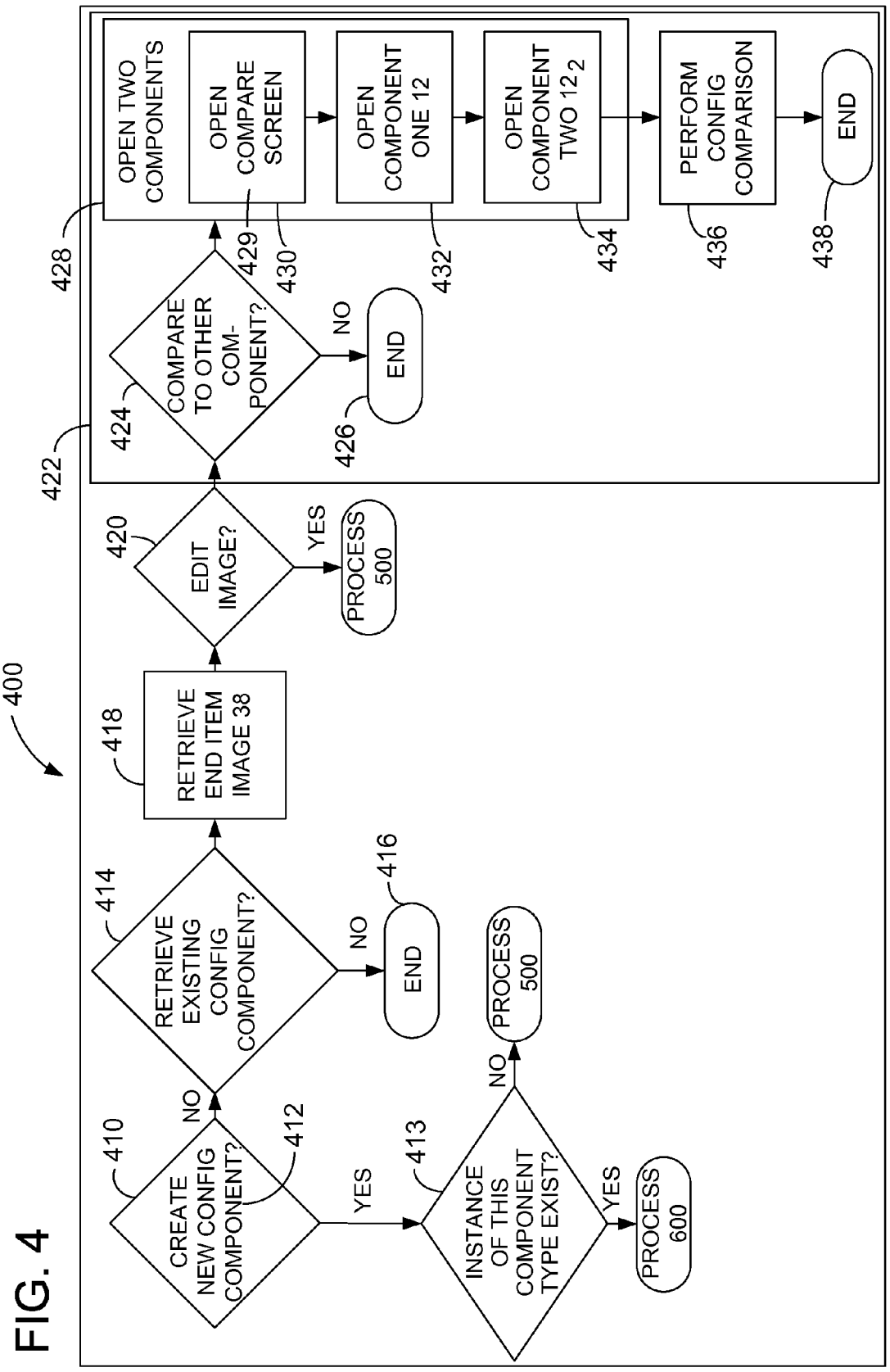

400
CREATE NEW CONFIG COMPONENT?
410
NO
412
YES
RETRIEVE EXISTING CONFIG COMPONENT?
414
NO
416
END
INSTANCE OF THIS COMPONENT TYPE EXIST?
413
NO
PROCESS 500
YES
PROCESS 600
RETRIEVE END ITEM IMAGE 38
418
EDIT IMAGE?
420
YES
PROCESS 500
422
COMPARE TO OTHER COM-PONENT?
424
NO
426
END
428
OPEN TWO COMPONENTS
OPEN COMPARE SCREEN
429
430
OPEN COMPONENT ONE 12
432
OPEN COMPONENT TWO 12 2
434
PERFORM CONFIG COMPARISON
436
END
438

FIG. 4

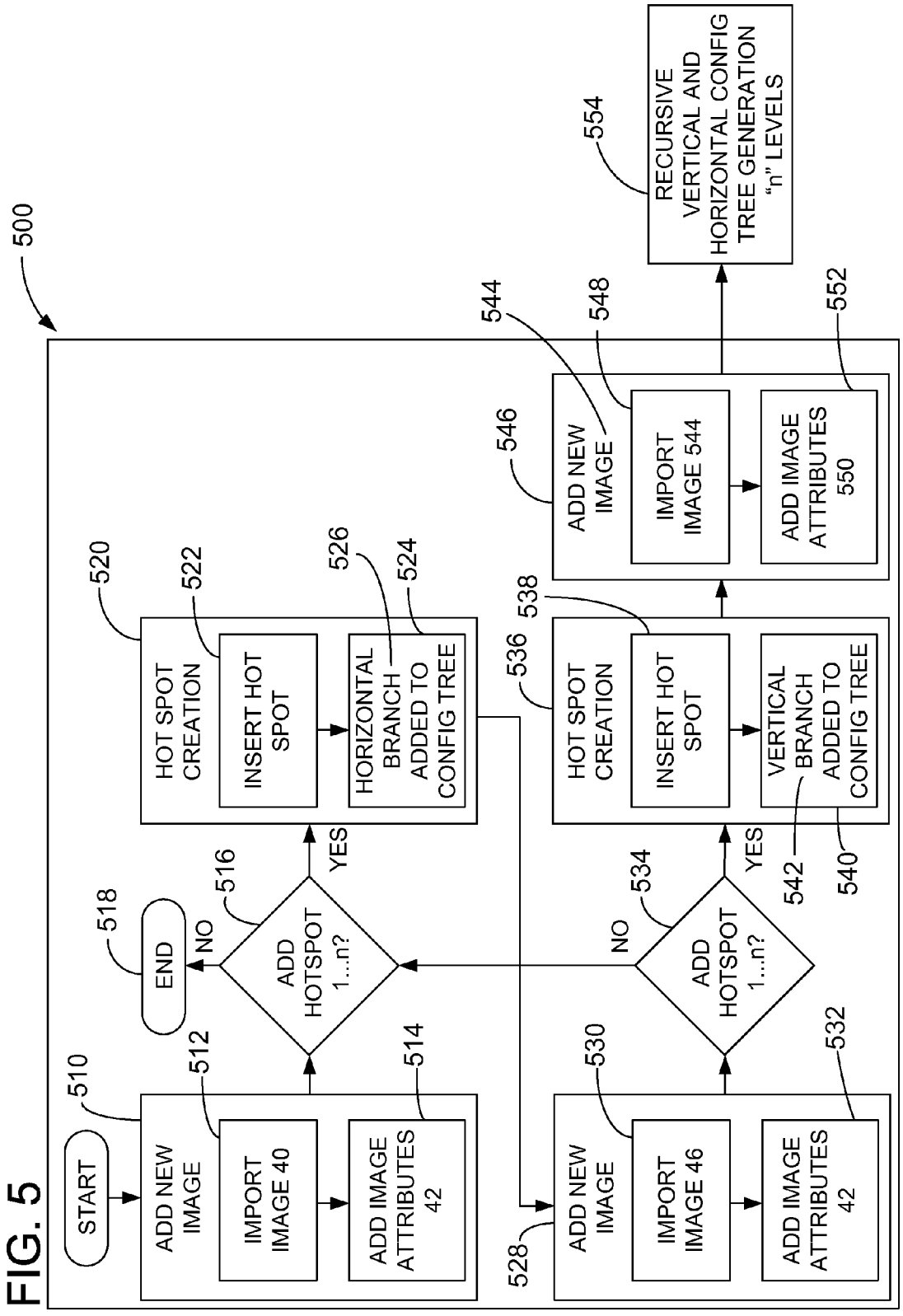

500
START
510
ADD NEW IMAGE
512
IMPORT IMAGE 40
514
ADD IMAGE ATTRIBUTES 42
ADD HOTSPOT 1...n?
516
NO
YES
518
END
520
HOT SPOT CREATION
522
INSERT HOT SPOT
524
HORIZONTAL BRANCH ADDED TO CONFIG TREE
526
528
ADD NEW IMAGE
530
IMPORT IMAGE 46
532
ADD IMAGE ATTRIBUTES 42
ADD HOTSPOT 1...n?
534
NO
YES
536
HOT SPOT CREATION
538
INSERT HOT SPOT
540
VERTICAL BRANCH ADDED TO CONFIG TREE
542
544
ADD NEW IMAGE
546
IMPORT IMAGE 544
548
ADD IMAGE ATTRIBUTES 550
552
RECURSIVE VERTICAL AND HORIZONTAL CONFIG TREE GENERATION "n" LEVELS
554

FIG. 5

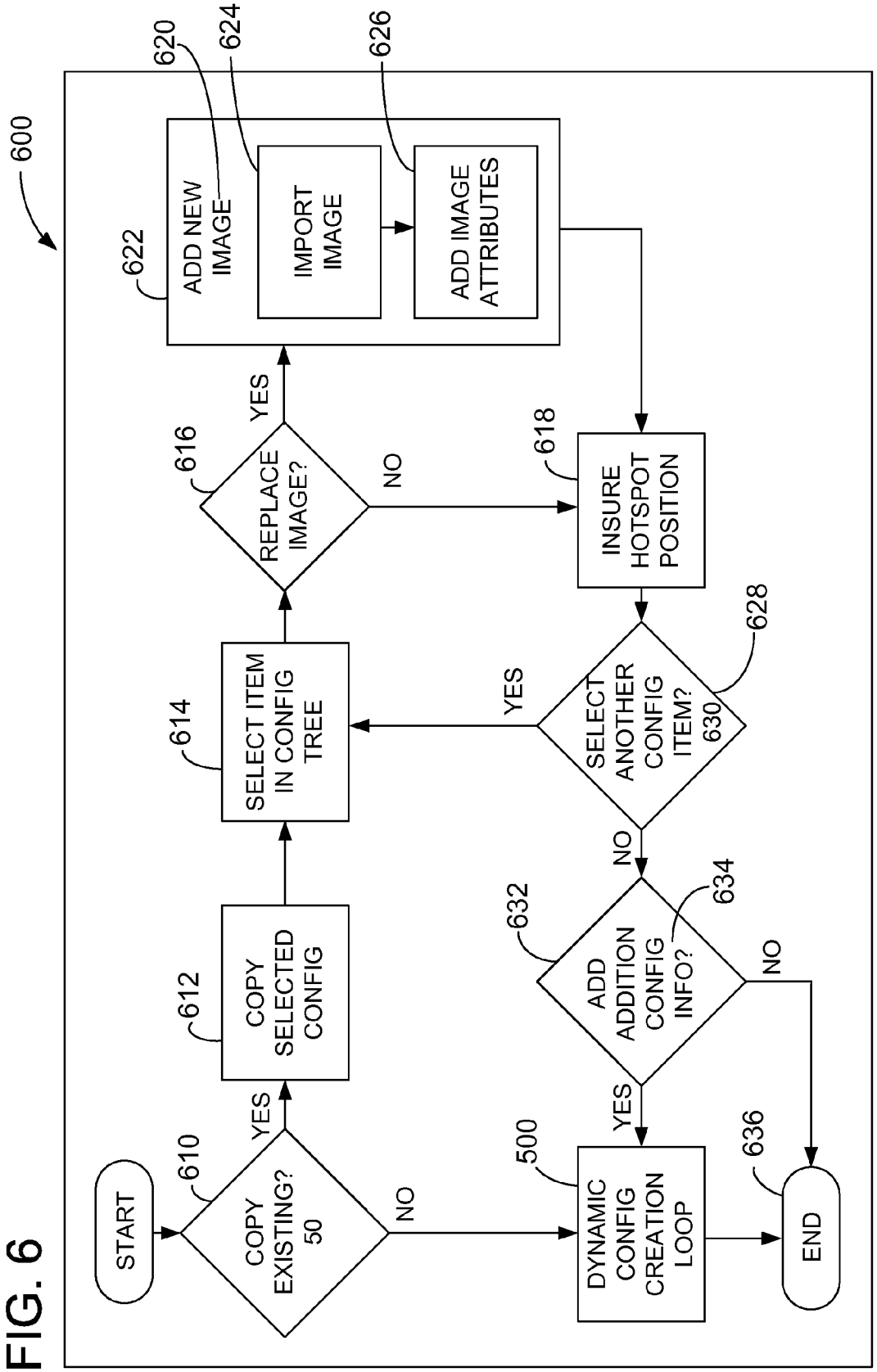

600
620
624
626
622
ADD NEW IMAGE
IMPORT IMAGE
ADD IMAGE ATTRIBUTES
YES
616
REPLACE IMAGE?
NO
618
INSURE HOTSPOT POSITION
614
SELECT ITEM IN CONFIG TREE
YES
628
SELECT ANOTHER CONFIG ITEM? 630
NO
612
COPY SELECTED CONFIG
632
634
ADD ADDITION CONFIG INFO?
NO
YES
START
610
COPY EXISTING? 50
YES
NO
500
DYNAMIC CONFIG CREATION LOOP
636
END

FIG. 6

FIG. 7A

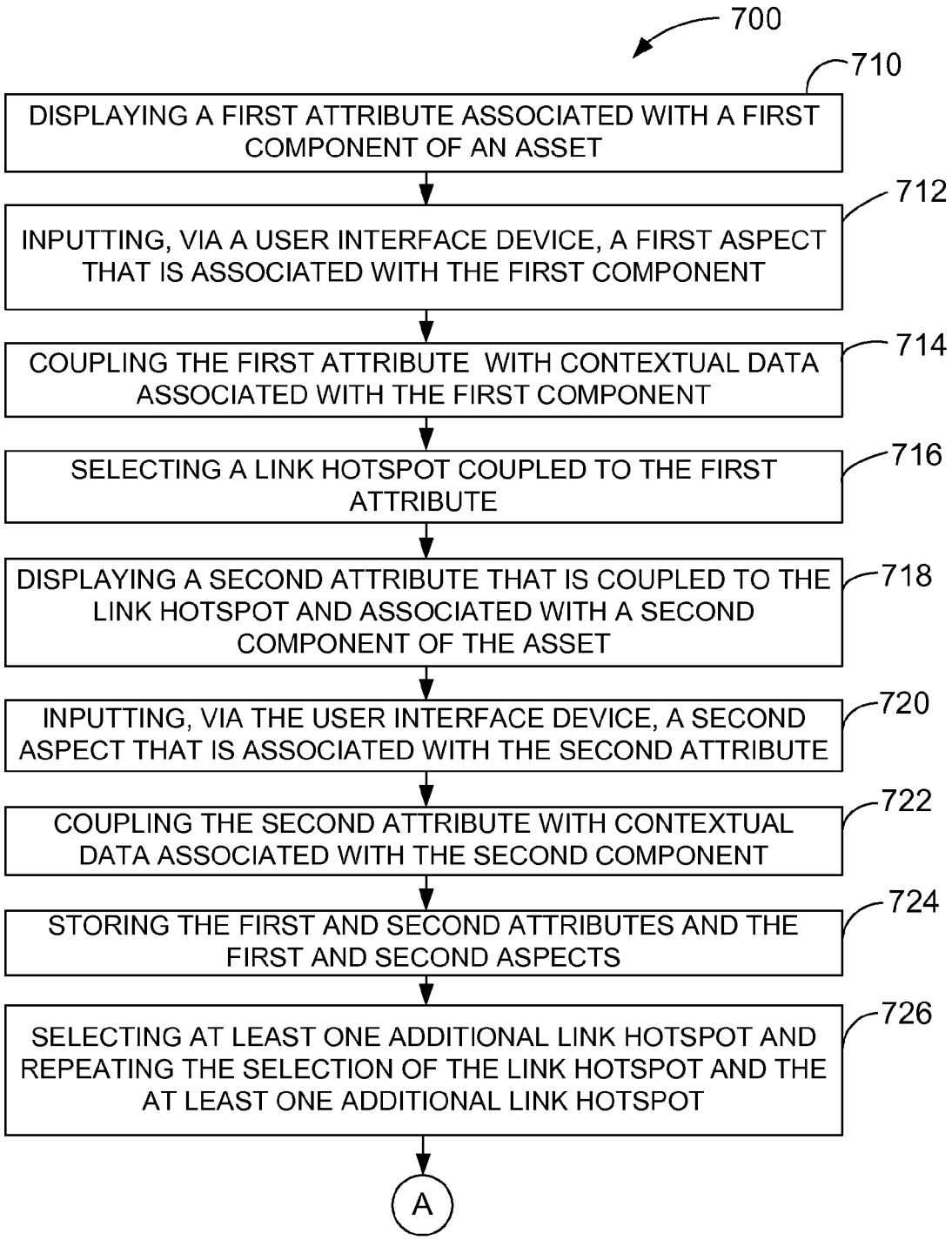

700
710
DISPLAYING A FIRST ATTRIBUTE ASSOCIATED WITH A FIRST COMPONENT OF AN ASSET
712
INPUTTING, VIA A USER INTERFACE DEVICE, A FIRST ASPECT THAT IS ASSOCIATED WITH THE FIRST COMPONENT
714
COUPLING THE FIRST ATTRIBUTE WITH CONTEXTUAL DATA ASSOCIATED WITH THE FIRST COMPONENT
716
SELECTING A LINK HOTSPOT COUPLED TO THE FIRST ATTRIBUTE
718
DISPLAYING A SECOND ATTRIBUTE THAT IS COUPLED TO THE LINK HOTSPOT AND ASSOCIATED WITH A SECOND COMPONENT OF THE ASSET
720
INPUTTING, VIA THE USER INTERFACE DEVICE, A SECOND ASPECT THAT IS ASSOCIATED WITH THE SECOND ATTRIBUTE
722
COUPLING THE SECOND ATTRIBUTE WITH CONTEXTUAL DATA ASSOCIATED WITH THE SECOND COMPONENT
724
STORING THE FIRST AND SECOND ATTRIBUTES AND THE FIRST AND SECOND ASPECTS
726
SELECTING AT LEAST ONE ADDITIONAL LINK HOTSPOT AND REPEATING THE SELECTION OF THE LINK HOTSPOT AND THE AT LEAST ONE ADDITIONAL LINK HOTSPOT
A

FIG. 7B

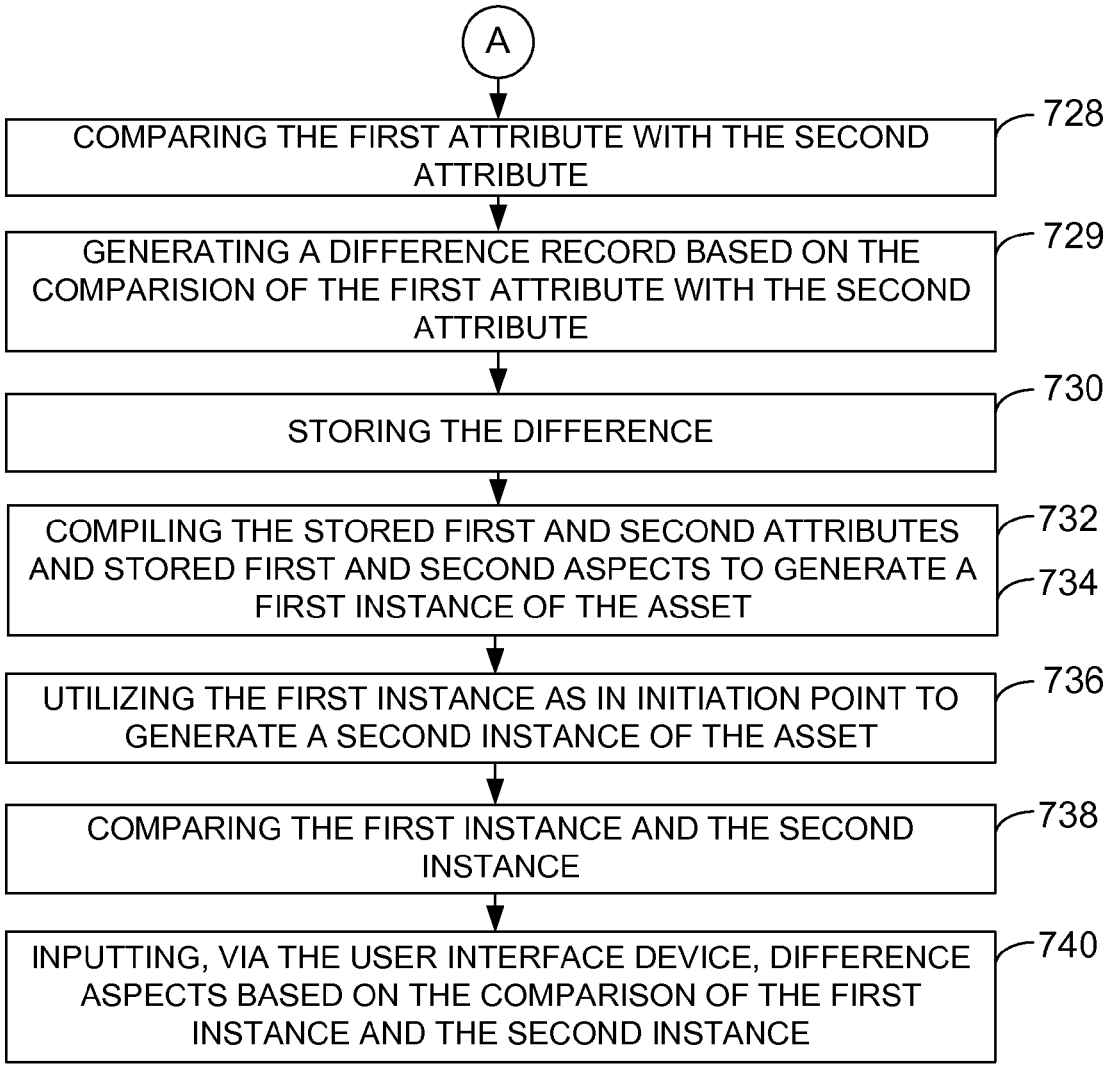

A
COMPARING THE FIRST ATTRIBUTE WITH THE SECOND ATTRIBUTE
728
GENERATING A DIFFERENCE RECORD BASED ON THE COMPARISION OF THE FIRST ATTRIBUTE WITH THE SECOND ATTRIBUTE
729
STORING THE DIFFERENCE
730
COMPILING THE STORED FIRST AND SECOND ATTRIBUTES AND STORED FIRST AND SECOND ASPECTS TO GENERATE A FIRST INSTANCE OF THE ASSET
732
734
UTILIZING THE FIRST INSTANCE AS IN INITIATION POINT TO GENERATE A SECOND INSTANCE OF THE ASSET
736
COMPARING THE FIRST INSTANCE AND THE SECOND INSTANCE
738
INPUTTING, VIA THE USER INTERFACE DEVICE, DIFFERENCE ASPECTS BASED ON THE COMPARISON OF THE FIRST INSTANCE AND THE SECOND INSTANCE
740

FIG. 8

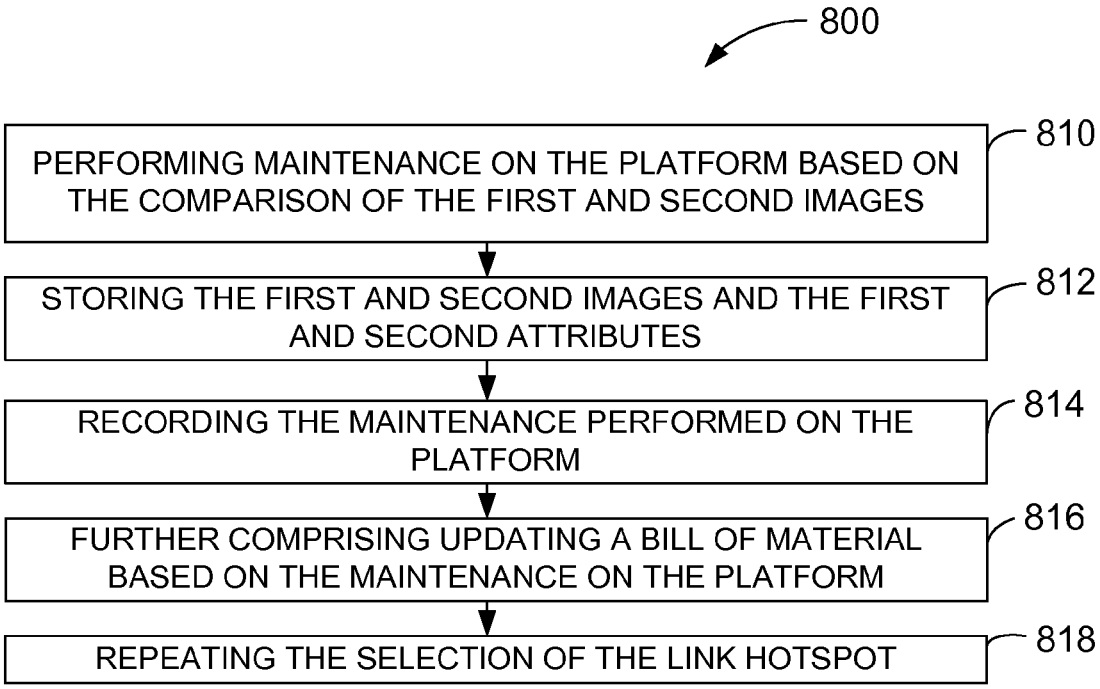

800
PERFORMING MAINTENANCE ON THE PLATFORM BASED ON THE COMPARISON OF THE FIRST AND SECOND IMAGES
810
STORING THE FIRST AND SECOND IMAGES AND THE FIRST AND SECOND ATTRIBUTES
812
RECORDING THE MAINTENANCE PERFORMED ON THE PLATFORM
814
FURTHER COMPRISING UPDATING A BILL OF MATERIAL BASED ON THE MAINTENANCE ON THE PLATFORM
816
REPEATING THE SELECTION OF THE LINK HOTSPOT
818

FIG. 9

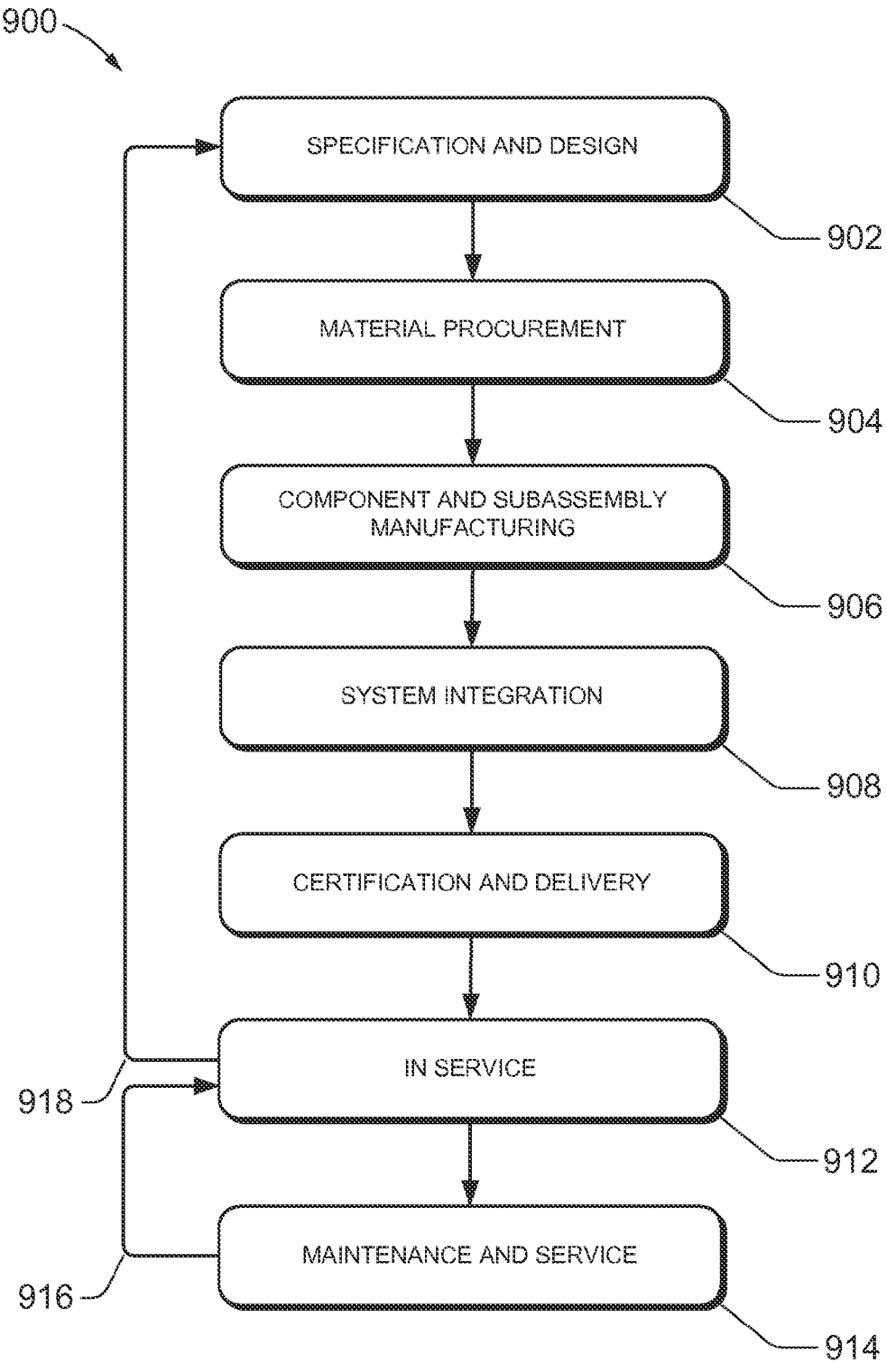

900
SPECIFICATION AND DESIGN
902
MATERIAL PROCUREMENT
904
COMPONENT AND SUBASSEMBLY MANUFACTURING
906
SYSTEM INTEGRATION
908
CERTIFICATION AND DELIVERY
910
IN SERVICE
912
MAINTENANCE AND SERVICE
914
916
918

FIG. 10

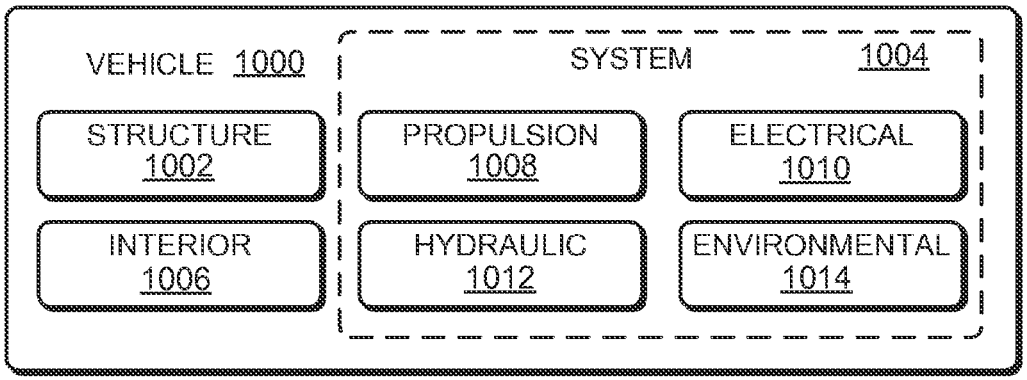
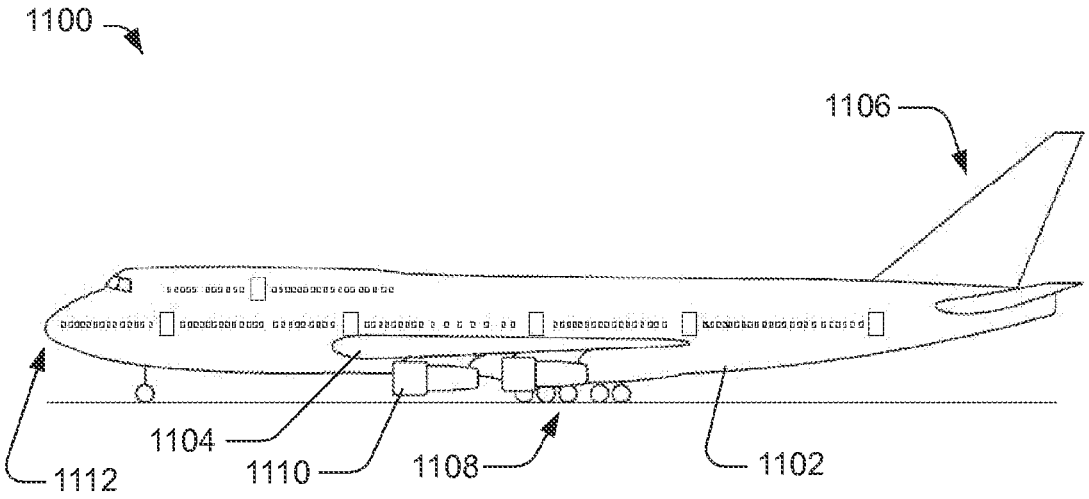

VEHICLE 1000
SYSTEM 1004
STRUCTURE 1002
PROPULSION 1008
ELECTRICAL 1010
INTERIOR 1006
HYDRAULIC 1012
ENVIRONMENTAL 1014

FIG. 11


1100
1106
1104
1112
1110
1108
1102

COMPONENT CONFIGURATION SYSTEM AND METHODS OF OPERATING SAME

BACKGROUND OF THE INVENTION

The present disclosure relates to a record system and more specifically, to methods and systems for recording a configuration record for an asset.

Asset maintenance and/or modification is an ongoing occurrence for assets that have a relatively long in-service lifespan and include a large capital investment, such that maintenance and/or modification is preferable over asset replacement. Assets such as aircraft, maritime vessels, automobiles, and other large investment assemblies routinely undergo maintenance and/or modification at regular intervals to maintain the vehicles and occasionally upgrade the vehicles with new components to improve vehicle performance.

In order to organize the configuration of components of the asset, some organizations obtain attributes of the asset, and then attempt to categorize those attributes after the fact into some sort of organization such as folders in a file cabinet or in 3-ring binders. More particularly, some of the attributes can be used to document configurations, for example wiring and/or hydraulics, of some known legacy assets and to allow for designs of modification kits over life of the asset. Some of the attributes, however, may be only available to only those aware of them, and may be left in a non-digital state which limits and/or prevents sharing the attributes with others in the organization. Moreover, some known attributes do not carry contextual information, such as component identification and/or positions within the asset limiting the effectiveness of the attributes.

Some organizations consult the attributes in developing proposed modification concepts to facilitate component identification and location, and in determining design space that is available for modifications, as well as configuration differences across vehicles. Some current methods, however, can be very time consuming, wrought with interpretation errors, and may not provide widespread access across the program. Organizations managing assets with known configurations may not have a structured method to manage captured general and specific asset aspects such as images, photographs, and X-rays. Moreover, known organizational methods may not include a structured method to efficiently organize attributes electronically as those attributes are collected. Further, some known programs include a regimented photo survey based on a predefined configuration. Deviations from this configuration, however, may have to be handled outside the scope of the organization. The reliance on administrative control, as opposed to an organized linkable architecture structure, however, may present errors in associating aspect information to the attributes resulting in uncertainty of specific configurations for the components.

A program to systematically collect and organize assets in a configuration that can be used by personnel throughout the organization would enhance better utilization of component data and lead to improved collaboration across the program. In addition, the ability to compare aspects of similar assets and different instances of assets, or the same aspects at different points in time would enhance organizational methods.

BRIEF DESCRIPTION OF THE INVENTION

In one aspect, a computer-implemented method of recording a configuration record for components of an asset is provided. The computer-implemented method includes displaying a first attribute associated with a first component of the asset and inputting, via a user interface device, a first aspect that is associated with the first component. A link hotspot that is coupled to the first attribute is selected. The computer-implemented method includes displaying a second attribute that is coupled to the link hotspot and associated with a second component of the asset. The computer-implemented method inputs, via the user interface device, a second aspect that is associated with the second attribute. The computer-implemented method includes storing the first and second attributes and the first and second aspects.

In another aspect, a computer system to record a configuration record for components of an asset is provided. The computer system includes a user interface device having a screen with a plurality of attributes and a plurality of link hotspots coupled to the plurality of attributes. A database is coupled to the user interface device, wherein the database includes an aspect associated with each of the plurality of attributes. The computer system includes a processor coupled to the user interface device and the database, wherein the processor is configured to couple the aspect to the plurality of link hotspots.

In a further aspect, a computer-implemented of evaluating a component of an asset is provided. The computer-implemented includes displaying a first attribute associated with a first component of the asset and inputting, via a user interface device, a first aspect that is associated with the first component. A link hotspot that is coupled to the first attribute is selected. The computer-implemented includes displaying a second attribute that is coupled to the link hotspot and associated with a second component of the asset. The computer-implemented inputs, via the user interface device, a second aspect that is associated with the second attribute. The computer-implemented includes storing the first and second attributes and the first and second aspects. The computer-implemented includes performing an evaluation on the asset based on the comparison of the first and second attributes.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a diagram of an exemplary configuration system that may be used to record components of an asset.

FIG. **2** illustrates a diagram of an exemplary user interface device of the configuration system shown in FIG. **1**.

FIG. **3** illustrates a diagram of an exemplary analyzer of the system shown in FIG. **1**.

FIG. **4** illustrates a flow diagram of an exemplary process to record a configuration and to compare asset components shown in FIG. **1**.

FIG. **5** illustrates a flow diagram of an exemplary process to generate a first instance of the configuration shown in FIG. **4**.

FIG. **6** illustrate a flow diagram of an exemplary process to record a second instance of configuration shown in FIG. **4**.

FIG. **7** illustrates a flow chart of an exemplary method that may be implemented to record an exemplary configuration system.

FIG. **8** illustrates a flow chart of an exemplary method that may be implemented to facilitate maintenance on an exemplary asset.

FIG. **9** illustrates a flow diagram of an exemplary vehicle production and service methodology.

FIG. **10** illustrates a schematic diagram of an exemplary vehicle asset.

FIG. **11** illustrates a side elevational view of an exemplary vehicle asset.

DETAILED DESCRIPTION OF THE INVENTION

The embodiments described herein relate to configuration systems and methods of operating the system. More particu-

larly, the embodiments relate to a system for generating, acquiring, organizing, recording and comparing attributes of components of an asset. Moreover, the embodiments are utilized in a variety of environments such as, but not limited to, military, civil, industrial, rail, shipping, aerodynamic and consumer environments. The embodiments described herein facilitate reducing maintenance time and downtime of assets to reduce maintenance costs and lost profits resulting from the asset downtime. Moreover, the embodiments described herein facilitate designing assets and/or asset components. A user interface device and host system facilitates part identification via a comparison process, which facilitates building a configuration record of the asset.

FIG. **1** illustrates a diagram of an exemplary configuration system **10** that is configured to facilitate configuring components $\mathbf{12}_{1 \ldots n}$ of an asset **14**. FIG. **2** illustrates a diagram of a user interface device **16** of system **10**. System **10** is configured to record a configuration record **18** of asset **14**. More particularly, system **10** is configured to at least acquire, create, edit, record, compare, display and store information associated with at least one component **12** of asset **14**. In the exemplary embodiment, asset **14** includes a vehicle such as, but not limited, to an aircraft, a spacecraft, a launch vehicle, seaborne or undersea vessel, ground based vehicle, mechanical devices and/or after machinery. Alternatively, asset **14** can include structures, such as buildings; and infrastructure, for example, bridges. Asset **14** can include any article containing subcomponents. System **10** includes a host system **20** and a legacy system **22** coupled to user interface device **16**. Alternatively, user interface device **16** can include host system **20** and legacy system **22** or capabilities of host system **20** and legacy system **22**.

User interface device **16** includes a central processing unit **24**, a surveyor **26**, a link hotspot **28**, a screen **30**, an input device **32**, such as for example a keyboard, and a database **34**. In the exemplary embodiment, central processing unit **24** includes units such as, but not limited to, a laptop and a smart phone. Surveyor **26** includes a data acquisition device **36** such as, but not limited to, a digital camera. Moreover, surveyor **26** can include other acquisition devices (not shown) that include little or no human interaction. More particularly, surveyor **26** can include a computer controlled camera (not shown) that is configured to acquire an image of a vehicle from various locations via a position system (not shown). The position system may use tracks, dollies, mechanical arms, and/or other apparatus to move the camera to positions that have known positional data (e.g., 3D coordinates, etc.). Surveyor **26** can use various cameras to simultaneously survey the vehicle, among other possible techniques to efficiently survey the vehicle.

In the exemplary embodiment, user interface device **16** is configured to acquire an attribute $\mathbf{38}_{1 \ldots n}$, such as a first attribute **40** of asset component **12**, wherein screen **30** is configured to display first attribute **40**. In another embodiment, database **34** can include first attribute **40** stored therein. First attribute **40** includes an image such as, for example, a two dimensional image of component **12**. Alternatively, first attribute **40** can include other configurations such as, but not limited to, non-two dimensional images, backscatter data, non-destructive evaluation data, an ultrasound image, a video image, a chemical composition image and a thermal image. First attribute **40** can include any configuration to enable system **10** to function as described herein.

In the exemplary embodiment, user interface device **16** includes a first aspect **42** coupled to first attribute **40**. First aspect **42** includes contextual data **44** associated with first component **12** of asset **14**. In the exemplary embodiment, contextual data **44** includes information described with component **12** such as, but not limited to, a serial number, a bill of material, a component name, a component description, a component position, a component material, design and/or repair and/or maintenance and/or replacement instructions. Alternatively, contextual data **44** can relate to any information associated with component **12**. User interface device **16** is configured to input, via keyboard, first aspect **42** associated with first attribute **40**. Alternatively, database **34** can be configured to store first aspect **42** for associating with first attribute **40**.

Aspect **42** can be acquired by a plurality of processes (not shown) such as, but not limited to, manual input by an operator (i.e., entering a serial number); automated entry (i.e., reading a bar code or a radio frequency identification tag); optical character recognition of text and a measurement device (distance measured by a distal micrometer). Aspect **42** can be acquired and coupled to attributes **38** by any process that enables system **10** to function as described herein.

Link hotspot **28** is coupled to first attribute **40**. More particularly, link hotspot **28** is configured to couple first attribute **40** to a second attribute **46** which is displayed via screen **30**. Second attribute **46** includes a two dimensional image of component **12**. Alternatively, second attribute **46** can include other configurations such as, but not limited to, non-two dimensional images, backscatter data, non-destructive evaluation data, an ultrasound attribute, a video attribute, a chemical composition attribute and a thermal attribute. Second attribute **46** can include any configuration to enable system **10** to function as described herein. In the exemplary embodiment, user interface device **16** includes a second aspect **43** coupled to second attribute **46**. Second aspect **43** includes contextual data **44** associated with second component $\mathbf{12}_2$ of asset **14**.

In the exemplary embodiment, first attribute **40** includes a plurality of link hotspots $\mathbf{28}_{1 \ldots n}$ that are configured to couple first attribute **40** to a plurality of second or additional attributes $\mathbf{46}_{1 \ldots n}$. Moreover, each attribute **46** of the plurality of attributes **46** includes a plurality of additional link hotspots $\mathbf{28}_{1 \ldots n}$. The coupling of attributes **40** and **46** with link hotspots **28** facilitates generating horizontal and/or vertical architectural branches **48** for attributes **40** and **46**, link hotspots **28**, and associated asset components **12**. In the exemplary embodiment, user interface device **16** is configured to record configuration record **18** by acquiring attributes **40** and **46**, aspects **42** and **43** and/or link hotspots **28** via commands entered in keyboard **32**.

In the exemplary embodiment, user interface device **16** is configured to generate and record a first instance **50** of configuration record **18**. First instance **50** includes predetermined information branches **48** of attributes **40**, link hotspots **28** and aspects **42** compiled together. Moreover, user interface device **16** is configured to generate and record a second instance **52** of configuration record **18**. Second instance **52** includes information branches **48** of attributes **46**, link hotspots **28** and aspects **43** compiled together. In the exemplary embodiment, branches **48** of first instance **50** include initiation points **54** for second instance **52**, wherein second instance **52** is configured to use and/or or inherit information branches **48** of first instance **50**. User interface device **16** is configured to compare and contrast first instance **50** and second instance **52** to facilitate analyzing components **12** and compiling differences between attributes, aspects and/or link hotspots between first instance **50** and second instance **52**. User interface device **16** is configured to generate a difference record **55** based on the comparison of first instance **50** and second instance **52**. In the exemplary embodiment, database **38** is configured to store

difference record **55**. Any level of previously identified instance of configuration record can be reused from asset to another asset (not shown).

As an illustrative example, first attribute **40** illustrates asset **14** (i.e., a vehicle) and first link hotspot **28** couples first attribute **40** to second attribute **46** that is illustrating asset component **12** (i.e., an engine of vehicle). A second link hotspot **58** of second attribute **46** is coupled to a third attribute **58** that illustrates another vehicle component **12** (i.e., an air filter of vehicle engine). A third link hotspot **60** of third attribute **58** is coupled to a fourth attribute **62** that illustrates another vehicle component **12** (i.e., an air filter pleat). Moreover, in the illustrative embodiment, aspects **42** associated with vehicle components **12** are coupled to respective attributes **40**, **46**, **58** and **62**. User interface device **16** is configured to repeat the process based on associated attributes and link hotspots **28** to generate and/or record configuration record **18** for vehicle components **12**.

In the illustrative embodiment, first instance **50** includes first attribute **40** (i.e., vehicle); second attribute **46** (i.e., engine) and third attribute **58** (i.e., air filter). In to addition to the structure of first instance **50**, second instance **52** can include other attributes (i.e., vehicles using a different type and/or quantify of air filter) to facilitate user interface device **16** to compare and contrast differences of first instance **50** and second instance **52** to analyze subsequent attributes of second instance **52**. Alternatively, first instance **50** and second instance **52** can include attributes of same component **12** of asset **14** at different points in time to compare and compile difference of attributes. More particularly, attributes of components **12** can be compared for condition changes during operating life of asset **14**. In this illustrative embodiment, user interface device **16** is configured to compare second instance **52** relating to an "as maintained/current" status of asset **14** as compared to first instance **50** relating to an "as designed" status. System **10** facilitates dynamic generation and/or recordation of structure and/or architecture of configuration record **18** to provide subsequent users to re-use all or part of any previously created and/or recorded structures for configurations **18**.

To facilitate generation and/or recordation of configuration record **18**, database **34** includes information compiled in a survey data **64**, a survey library **66** and a survey configuration **68**. User interface device **16** is configured to communicate survey data **64**, survey library **66** and survey configuration **68** to host system **20**. Survey data **64** includes information collected from observing existing components **12** and/or complete asset **14** and survey library **66** includes existing information. In the exemplary embodiment, survey data **64** includes photographs or other imagery, measurements, and other information gained through human-based and/or machine-based observation of asset **14**. Survey library **66** includes various 2D imagery (e.g., digital photography, thermo photography, x-ray imaging, etc.), or other types of imagery (e.g., optical metrology, etc.) that may be used to identify unknown information during a subsequent inquiry via a comparison process. The data in survey library **66** may be supplemented with additional aspects, such as part numbers, part descriptions, measurements, position information, or other data relevant to component **12**.

Survey configuration **68** includes 2D imagery of component **12** that may be scheduled for maintenance. Alternatively, survey configuration **68** can include 2D imagery to design aspect **14**. In the exemplary embodiment, survey library **66** and survey configuration **68** include other data such as position information, human generated reports, reverse engineering data, measurements, part identifiers (e.g., item number, etc.), or other data extracted from asset **14** (or portion thereof) via a human or machine. Host system **20** is configured to compare survey configuration **68** to other data, such as survey library **66**, to populate fleet maintenance data and determine configuration record **18** of component **12** that has scheduled maintenance.

Legacy system **22** is configured to communicate additional information to user interface device **16** and/or host system **20**. Legacy system **22** includes integrated and/or disparate systems (not shown) made up of servers that host a wide range of part information. In the exemplary embodiment, legacy system **22** includes data such as, but not limited to, CAD data **70**, imagery **72**, and bill of materials (BOMs) **74**. CAD data **70** includes 2D and 3D models of component **12** and/or asset **14**. Imagery **72** includes photographs, optical metrology, x-rays, or other imagery that may provide graphical information about component **12**. BOM **74** provides non-graphical information associated with component **12**.

Host system **20** includes one or more processors **76** and memory **78**. Memory **78** includes applications, modules, and/or data. More particularly, memory **78** includes a fleet maintenance application **80**, which may facilitate populating fleet maintenance data by collecting information about asset **14** from user interface device **16** and/or legacy system **22**. Fleet maintenance application **80** includes a number of modules such as a data collector **82**, a survey module **84**, a data analyzer **86**, and a configuration builder **88**. Alternatively, memory **78** may include applications, modules and/or data for an initial design of aspect **14**. Data collector **82** is configured to facilitate obtaining data from legacy system **22**, wherein data collector **82** may format data or otherwise modify the data to enable further analysis of the data. For example, imagery data may be converted to a particular format of attributes, which may enable rapid comparison of attributes or feature identification within the attributes.

Survey module **84** is configured to access survey data **64** and/or survey library **66** and to interact user interface device **16** to facilitate generating survey configuration **68**. Data analyzer **86** is configured to compare survey configuration **68** to existing data from various sources (e.g., survey library **66** and/or legacy system **22**) to facilitate identifying component **12**. For example, data analyzer **86** is configured to determine a unique feature of a 2D attribute of component **12** obtained from survey configuration **68**. Data analyzer **86** compares feature to attributes stored in survey library **66** to facilitate recording a list of matching parts, which are further analyzed to determine which part is included in survey configuration **68**. Configuration builder **88** is configured to create configuration record **18** of asset **14** based on the output of data analyzer **86**. In one embodiment, configuration builder **88** is configured to facilitate generating revised BOM **74** (or complete BOM in some instances). Alternatively, configuration builder **88** can generate a 3D model (not shown) of asset **14**, such as, for example, a layout model, an exploded view model, CAD model, or rudimentary 3D model of asset **14**.

FIG. **3** illustrates a schematic diagram of data analyzer **86**. Data analyzer **86** is configured to receive survey configuration **68**, which may be obtained by user interface device **16** (shown in FIG. **1**) under the direction of survey module **84** (shown in FIG. **1**). Survey module **84** is configured to direct surveyor to generate and/or record survey data of a particular aspect of survey configuration **68** (e.g., photograph of component **12** from a particular perspective), which may include 2D imagery of asset **14** designated for design and/or maintenance.

Data analyzer **86** is configured to receive data from existing data sources **92**, such as survey library **66** and existing fleet

data **90**. Fleet data **90** includes existing definition data stored and managed by the legacy system **22** (shown in FIG. **1**). Data analyzer **86** is configured to compare data received from survey configuration **68** to survey library **66** to identify asset component **12**. Data analyzer **86** is configured to compare characteristic features of a survey configuration attribute to survey attributes in survey library **66** to identify component **12** to obtain further information about component **12** from the existing data sources **92** including CAD data **70**, imagery **72**, and/or BOM **74**.

In the exemplary embodiment, data analyzer **86** is configured to obtain and manipulate spatial/position information obtained from survey configuration **68** in reference to the existing fleet data **90**. Data analyzer **86** is configured to facilitate construction of a 3D model (e.g., via configuration builder **88**) by obtaining component **12** information and combining it with spatial/position information. Data analyzer **86** is configured to manipulate data to enable updating BOM **74** and generate at least a portion of a 3D model of asset **14** designated for design and/or maintenance by comparing survey configuration **68** to existing data sources **92**.

FIG. **4** illustrates a flow diagram of an exemplary process **400** to record configuration record **18** and compare asset components **12**. FIG. **5** illustrates a flow diagram of an exemplary process **500** to record first instance **50** of configuration record **18**. FIG. **6** illustrates a flow diagram of an exemplary process **600** to record second instance **52** of configuration record **18**. Processes **400**, **500** and **600** are illustrated as a collection of blocks in a logical flow graph, which represent a sequence of operations that can be implemented in hardware, software, or a combination thereof. In the context of software, the blocks represent computer-executable instructions that, when executed by one or more processors, cause the one or more processors to perform the recited operations. Generally, computer-executable instructions include routines, programs, objects, components and data structures that perform particular functions or implement particular abstract data types. The order in which the operations are described is not intended to be construed as a limitation, and any number of the described blocks can be combined in any order and/or in parallel to implement the process. Other processes described throughout this disclosure, in addition to process processes **400**, **500** and **600**, shall be interpreted accordingly. Processes **400**, **500** and **600** may be performed, at least in part, by user interface device **16** (shown in FIG. **1**).

FIG. **4** illustrates process **400** that is configured to acquire and/or compare first attribute **40** and second attribute **46** of configuration record **18**. If at decision block **410**, the decision is made to generate a new configuration **412**, process **400** proceeds to decision block **413**. At decision block **413**, a determination is made as to whether an instance, first example, first instance **50** or second instance **52**, of configuration **412** exists. If not, process **400** proceeds to process **500** (shown in FIG. **5**) as described herein. If instance configuration already exists, process **400** proceeds to process **600** (shown in FIG. **6**) as described herein.

If at decision block **410**, the decision is made not to generate new configuration **412**, a determination is made whether to retrieve existing configuration record **18** for component **12**. If not, then at block **414**, user interface inquires whether to retrieve existing attribute **38** for component **12**. If not, process **400** ends at block **416**. If user decides to retrieve existing attribute **38** for component **12**, user interface device **16** retrieves attribute **38** at block **418**. At decision block **420**, a determination is made to edit attribute **38**. If user decides to edit attribute **38**, process **400** proceeds to process **500** (shown in FIG. **5**) as described herein.

If the determination is not to edit attribute **38**, process **400** proceeds to a comparison configuration process **422**. At decision block **424**, a determination is made whether to compare component **12** to another component $\mathbf{12}_n$. If not, process **400** ends at block **426**. If user decides to compare components **12** at block **428**, user interface device **16** opens a compare screen **429** at block **430**. More particularly, user interface opens first attribute **40** associated with first component **12** at block **432** and opens second attribute **46** associated with second component $\mathbf{12}_2$ at block **434**. User interface device **16** is configured to compare at block **436** between first attribute **40** and second attribute **46**. User interface device **16** is configured to compile, analyze, record, display and/or store in database differences of first instance **50** and second instance **52**. Upon completion of comparison process **120**, process **400** ends at block **130**.

FIG. **5** illustrates process **500** to record first instance **50** of asset configuration record **18**. In the exemplary embodiment, process **500** facilitates importing attributes **38**, adding aspects **42** and inserting link hotspots **28** to user interface device **16**. At block **510**, first attribute **40** is coupled to user interface device **16**. More particularly, first attribute **40** is imported and coupled to user interface device **16** at block **512**. At block **514**, aspect **42** is coupled to first attribute **40**. Moreover, at decision block **516**, a determination is made to add link hotspot $\mathbf{28}_{1 \ldots n}$. If link hotspot **28** is not added, process **500** ends at block **518**. If user decides to add link hotspot **28**, link hotspot $\mathbf{28}_n$ is created at block **520**. More particularly, link hotspot **28** is coupled to first attribute **40** at block **522**.

Link hotspot **28** is designated at block **524** as a branch **526** coupled to configuration record **18**. In the exemplary embodiment, subsequent link hotspot $\mathbf{28}_n$ is coupled to first attribute **40** as horizontal branch **526** to configuration record **18**. Alternatively, link hotspot **28** can be coupled to first attribute **40** as a vertical branch (not shown) to configuration. For link hotspot **28**, second attribute **46** is coupled to user interface device **16** at block **528**. Second attribute **46** is imported at block **530** and aspect **43** is coupled to second attribute **46** at block **532**.

At decision block **534**, a determination is made whether to couple additional link hotspot $\mathbf{28}_{1 \ldots n}$ to configuration record **18**. If not, process **500** is configured to facilitate repeating cycle by proceeding to decision block **516**. If user decides to add link hotspot **28**, link hotspot $\mathbf{28}_n$ is generated at block **536**. More particularly, link hotspot $\mathbf{28}_n$ is coupled to attribute at block **538**. In the exemplary embodiment, link hotspot $\mathbf{28}_n$ is coupled to attribute at block **540** as a vertical branch **542** of configuration record **18**. Alternatively, link hotspot **28** can be coupled as a horizontal branch configuration (not shown).

For link hotspot $\mathbf{28}_n$, another attribute **544** is coupled to user interface device **16** at block **546**. Attribute **544** is imported at block **548** and aspect **550** is coupled to attribute **544** at block **552**. The generation of link hotspots **28** and addition of respective attributes **544** and aspects **550** is repeated by user interface device **16** to facilitate generating recursive vertical and horizontal branches **48** of configuration record **18** for $\text{levels}_{1 \ldots n}$ at block **554**.

FIG. **6** is illustrates process **600** to record second instance **52** of existing configuration record **18**. At decision block **610**, a determination is made as to whether to copy first instance **50** of configuration record **18**. If a decision is made to not copy existing first instance **50**, then process **600** is configured to proceed to process **500** (shown in FIG. **5**). In the alternative, at block **612**, existing configuration record **18** is replicated.

Attribute **38** is selected from configuration at block **614**. At decision block **616**, a determination is made whether to replace attribute **38**. If not, then process **600** is configured to

couple link hotspot **28** to attribute **38** at block **618**. Alternatively, if a decision is to replace attribute **38**, process **600** is configured to couple new attribute **620** at block **622**. More particularly, attribute **620** is imported and coupled to user interface at block **624** and aspect **42** is coupled to attribute at block **626**.

After coupling aspect **42** to attribute **620**, process **600** is configured to insure link hot spot position at block **618**. At decision block **628**, a determination is made whether to select another attribute **630** in configuration. If another attribute **630** is selected, process **600** is configured to facilitate repeating attribute selection loop by proceeding to block **614**. If a decision is made not to select another attribute **630** at block **628**, then at decision block **632**, a determination is made to generate another instance **634** of configuration. If not, process **600** ends at block **636**. Alternatively, if user decides to generate another instance of configuration, process **600** is configured to repeat process **500** (shown in FIG. **5**).

To facilitate processes **400**, **500** and **600**, data analyzer **86** (shown in FIGS. **1** and **3**) is configured to facilitate developing a characterization of components **12** of asset **14** by comparing obtained data (e.g., the survey configuration **68**) to recognized features contained in collected data (e.g., the survey library **66**).

Data analyzer **86** is configured to build database **34** of components **12**. Database **34** of components **12** may include portions of the survey library **66**, data from legacy system **22**, and other data related to vehicle components **12** to assist in design and/or maintenance of asset **14** having component **12**. Database **34** is configured to enable access of component data in response to the survey configuration **68** of asset **14**. Using a feature learning process (not shown), data analyzer **86** is configured to apply recognition algorithms to 2D imagery to build database **34** having parameters peculiar to individual components **12**.

Data analyzer **86** is configured to compare survey configuration **68** to database **34** to identify component **12**. For example, survey configuration **68** of component **12** may include multiple photographs of the component **12**. Using known techniques including attribute recognition (e.g., algorithms similar to those used for face recognition, fingerprinting, etc.), survey configuration imagery (e.g., photographs, etc.) may be matched to attribute **38** in database **34** of component **12** (from the survey library **66**). The comparison results in a conclusive data acquisition if a match is successful or an inclusive acquisition if a match is not successful with 2D imagery in database **34** of components **12**. For example, a wheel may be identified by a component **12** identifier shown in attribute of component **12** (and extracted via character recognition).

In the exemplary embodiment, a numerical analysis is performed when matching the survey configuration **68** to the survey library **66**, which may result in a match score (not shown). The match score may then be compared to a threshold value, where the match score indicates a match is made if it reaches or exceeds the threshold score. If a match is not made, or an insufficient match score is obtained, additional data may be required. The additional data may be obtained by human interaction, further surveys, and so forth. If additional data is necessary, the data may be used to enhance database **34** of components **12** upon completion of the acquisition of addition data. Data analyzer **86** updates known data to enhance the system for future use.

If a match is successful and additional data is not desired or necessary, then data analyzer **86** continues to determine position data. The position data may enable assembling attributes of components **12** into a 3D model. In some embodiments, the position data may include position information from other data sources, such as CAD data **70**. Position data may also be derived from the 2D imagery when the position of the imaging device (e.g., digital camera, x-ray, etc.) is known. For example, when cameras are positioned in known positions relative to a component (fixed camera positions, known positions of movable cameras attached to a movable arm, track, etc.) the position of component **12** may be derived from collected data to enable assembling the 3D model.

Data analyzer **86** is configured to determine the identity of one or more components **12** from the survey configuration **68** to create configuration record **18**. Configuration record **18** includes a component identifier (e.g., component number, component name), component position data, and/or other data associated with the component, assembly, or vehicle. Ultimately, via the configuration builder **88**, the configuration information may be used to generate revised BOM **74**, or when including position data, the configuration information may be used to generate the 3D model of asset **14**.

FIG. **7** illustrates an exemplary method **700** of generating configuration record **18** of asset components **12** via user interface device **16**. During operations such as, but not limited to, design, maintenance, repair and/or replacement operations, user interface device **16** is utilized to facilitate generating, acquiring, organizing, recording, display and/or comparing attributes associated with asset components **12**. In the exemplary method, first attribute **40** that is associated with first component **12** is acquired **710**. Method includes inputting **712**, via user interface device **16**, first aspect **42** that is associated with first component **12**. In the exemplary method, first aspect **42** is coupled **714** to first attribute **40** with contextual data **44** associated with first component **12**.

Link hotspot **28** which is coupled to first attribute **40** is selected **716** and second attribute **46** associated with second component **12** is acquired **718**. Method includes inputting **720**, via user interface device **16**, second aspect **43** that is associated with second component 12_2. In the exemplary embodiment, second aspect **42** is coupled **722** to second attribute **46** with contextual data **44** associated with second component 12_2. First and second attribute **40** and **46** and respective first and second aspects **42** and **43** are stored **724** in database **34** of user interface device **16**.

In the exemplary method, a plurality of link hotspots **28** is coupled to second attribute **46** and/or to subsequent attributes 46_n. Method **700** includes selecting **726** at least one additional link hotspot **28** of the plurality of link hotspots **28** that are coupled to second attribute **46** and/or subsequent attributes **46**, via user interface device **16**. User interface device **16** is configured to facilitate repeating the selection of link hotspots **28** and acquire subsequent attributes associated with asset components **12**.

After first and second attributes **40** and **46** are stored, method **700** includes comparing **728** first attribute **40** and second attribute **46** via user interface device **16**. Method generates **729** difference record **55** based on the comparison of first attribute **40** and second attribute **46**. Method further includes storing **730** difference record **55** in database **34**.

In the exemplary embodiment, method **700** includes processor compiling **732** stored first and second attributes **40** and **46** and associated first and second aspects **42** and **43** to facilitate generating and/or recording **734** first instance of asset **14**. Method **700** includes utilizing **736** first instance **50** as initiation point **54** to facilitate generating and/or recording second instance **52** of asset **14**. First instance **50** and second instance **52** are compared **738** to facilitate inputting **740**, via user interface device **16**, difference aspects based on the comparison of first instance **50** and second instance **52**.

FIG. **8** illustrates an exemplary method **800** of evaluating asset component **12** for maintenance. After system **10** generates asset configuration record **18** (shown in FIG. **7**), method **800** includes evaluating **810** needs of asset **14** based on comparison of first attribute **40** and second attribute **46**. In one embodiment, method **800** includes performing maintenance **811** on asset **14**. Method **800** further includes storing **812** first attribute **40** and second attribute **46** in database **34**. After maintenance, attributes **40** and **46** are recorded in database **34**. Method **800** includes updating **816** bill of material **74** based on the maintenance performed on asset **14**. Method **800** repeats selection **818** of link hotspots **28** to continue evaluating maintenance needs for other components **12**.

Embodiments of the disclosure may be described in the context of an illustrative vehicle manufacturing and service process **900** as shown in FIG. **9** and an illustrative vehicle **1000** as shown in FIG. **10**. During pre-production, exemplary process **900** may include specification and design **902** of vehicle **1000** and material procurement **904**. During production, component **12** and subassembly manufacturing **906** and system integration **908** of vehicle **1000** are conducted. Thereafter, vehicle **1000** may go through certification and delivery **910** in order to be placed in-service **912**. While in-service by a customer, vehicle **1000** is scheduled for routine maintenance and service **914** (which may also include modification, reconfiguration, refurbishment, and so on). In accordance with various embodiments, an analysis system (not shown) may be employed at the in-service **912** in anticipation of vehicle maintenance and service **914**. In some embodiments, vehicle **1000** may undergo maintenance during scheduled or unscheduled intervals via a route **916** that links the in-service operation **912** and the maintenance and service operations **914** to create a recursive process. Vehicle **1000** may also undergo an upgrade via a route **918** that links the in-service operation **912** and the specification and design operation **902** to create another recursive process. The upgrade may include an installation of a new system or component on an existing vehicle.

Each of the processes of method **900** may be performed or carried out by a system integrator, a third party, and/or an operator (e.g., a customer). For the purposes of this description, a system integrator may include without limitation any number of vehicle manufacturers and major-system subcontractors; a third party may include without limitation any number of venders, subcontractors, and suppliers; and an operator may be an airline, leasing company, military entity, service organization, and so on.

The various techniques (e.g., the processes **400**, **500**, and **600**) embodied herein may be employed during any one or more of the stages of the production and service method **900**. For example, one or more of embodiments of fleet maintenance application, may be utilized while vehicle **1000** is in-service **912** and/or at the maintenance and service **914**.

As shown in FIG. **10**, vehicle **1000** includes a structure (frame) **1002** with a plurality of systems **1004** and an interior **1006**. Examples of systems **1004** include one or more of a propulsion system **1008**, an electrical system **1010**, a hydraulic system **1012**, and an environmental system **1014**. Any number of other systems may be included. The principles of the invention may be applied many industries, such as the aerospace industry, the automotive industry, and so forth.

FIG. **11** is a side elevational view of an illustrative aircraft **1100**, which may experience fleet maintenance that is performed using the techniques disclosed herein. The use of data analyzer **86**, surveyor **26**, and legacy system **22** (shown in FIG. **1**) facilitated identifying parts to create the revised BOM **74** and create the 3D model using 2D imagery and position information as disclosed herein.

In this embodiment, the aircraft **1100** includes a fuselage **1102** including wing assemblies **1104**, a tail assembly **1106**, and a landing assembly **1108**. The aircraft **1100** further includes one or more propulsion units **1110**, a control system **1112**, and a host of other systems and subsystems that enable proper operation of the aircraft **1100**. One should appreciate that many parts included in an aircraft may be identified using 2D imagery using the techniques disclosed herein. In general, the various components **12** and subsystems of the aircraft **1100** may be of known construction and, for the sake of brevity, will not be described in detail herein.

Although the aircraft **1100** shown in FIG. **11** is generally representative of a commercial passenger aircraft; however, the embodiments described herein may be applied to the design, maintenance, manufacture, and assembly of other passenger aircraft, fighter aircraft, cargo aircraft, rotary aircraft, and any other types of manned or unmanned aircraft, as well as other types of vehicles disclosed herein.

Exemplary embodiments of systems and methods for a configuration system are described above in detail. The systems and methods are not limited to the specific embodiments described herein, but rather, components of systems and/or steps of the method may be utilized independently and separately from other components and/or steps described herein. Each component and each method step may also be used in combination with other components and/or method steps. Although specific features of various embodiments may be shown in some drawings and not in others, this is for convenience only. Any feature of a drawing may be referenced and/or claimed in combination with any feature of any other drawing.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A computer-implemented method of recording a configuration record for components of an asset, said computer-implemented method comprising:

displaying a first attribute associated with a first component of the asset;

inputting, via a user interface device, a first aspect that is associated with the first component;

determining a link hotspot on the first attribute, wherein the link hotspot is at a location of a second component of the asset;

coupling a second attribute associated with a second component of the asset to the link hotspot;

inputting, via the user interface device, a second aspect that is associated with the second attribute; and

storing the first and second attributes and the first and second aspects.

2. The computer-implemented method of claim **1** wherein inputting the first aspect comprises coupling the first attribute with contextual data associated with the first component and

inputting the second aspect comprises coupling the second attribute with contextual data associated with the second component.

3. The computer-implemented method of claim **1** further comprising comparing the first attribute with the second attribute.

4. The computer-implemented method of claim **3** further comprising generating a difference record based on the comparison of the first attribute with the second attribute.

5. The computer-implemented method of claim **1** further selecting at least one additional link hotspot coupled to the second attribute.

6. The computer-implemented method of claim **5** further comprising repeating the selection of the link hotspot and the at least one additional link hotspot.

7. The computer-implemented method of claim **1** further comprising coupling the stored first and second attributes and stored first and second aspects to record a first instance of the asset.

8. The computer-implemented method of claim **7** further comprising utilizing the first instance as an initiation point to generate a second instance of the asset.

9. The computer-implemented method of claim **8** further comprising comparing the first instance and the second instance.

10. The computer-implemented method of claim **9** further comprising generating, via the user interface device, difference aspects based on the comparison of the first instance and the second instance.

11. A computer system to record a configuration record for components of an asset, said computer system comprising:

a user interface device comprising a screen configured to display a first attribute of a first component of the asset;

a database coupled to said user interface device, said database comprising an aspect associated with each of said plurality of attributes; and

a processor coupled to said user interface device and said database, said processor configured to determine a link hotspot on said first attribute at a location of a second component of the asset, to couple said aspect to said link hotspot, and to couple a second attribute associated with the second component of the asset to said link hotspot.

12. The computer system of claim **11** wherein said user interface is configured to:

input a first aspect that is associated with the first component;

select the link hotspot coupled to said first attribute;

display the second attribute associated with the second component of the asset;

input a second aspect that is associated with said second attribute; and

store said first and second attributes and said first and second aspects.

13. The computer system of claim **12** wherein said first and second attributes comprise at least one of a two-dimensional image, a non-two dimensional image, a photograph, a backscatter data, a non-destructive evaluation data, an ultrasound attribute, and a video attribute.

14. The computer system of claim **12** wherein said first and second aspects comprise contextual data relating to at least one of said first and second attributes.

15. The computer system of claim **14**, wherein said contextual data comprises at least one a serial number, a component position and a component material.

16. A computer-implemented method of evaluating a component of an asset, said computer-implemented method comprising:

displaying a first attribute associated with a first component of the asset;

inputting, via a user interface device, a first aspect that is associated with the first component;

determining a link hotspot on the first attribute, wherein the link hotspot is at a location of a second component of the asset;

coupling a second attribute associated with a second component of the asset to the link hotspot;

inputting, via the user interface device, a second aspect that is associated with the second attribute;

comparing the first attribute and the second attribute; and

performing an evaluation on the asset based on the comparison of the first and second attributes.

17. The computer-implemented method of claim **16** further comprising storing the first and second attributes and the first and second aspects.

18. The computer-implemented method of claim **16** further comprising performing maintenance on the asset.

19. The computer-implemented method of claim **18** further comprising recording the maintenance performed on the asset.

20. The computer-implemented method of claim **16** further comprising repeating the selection of the link hotspot.

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